BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

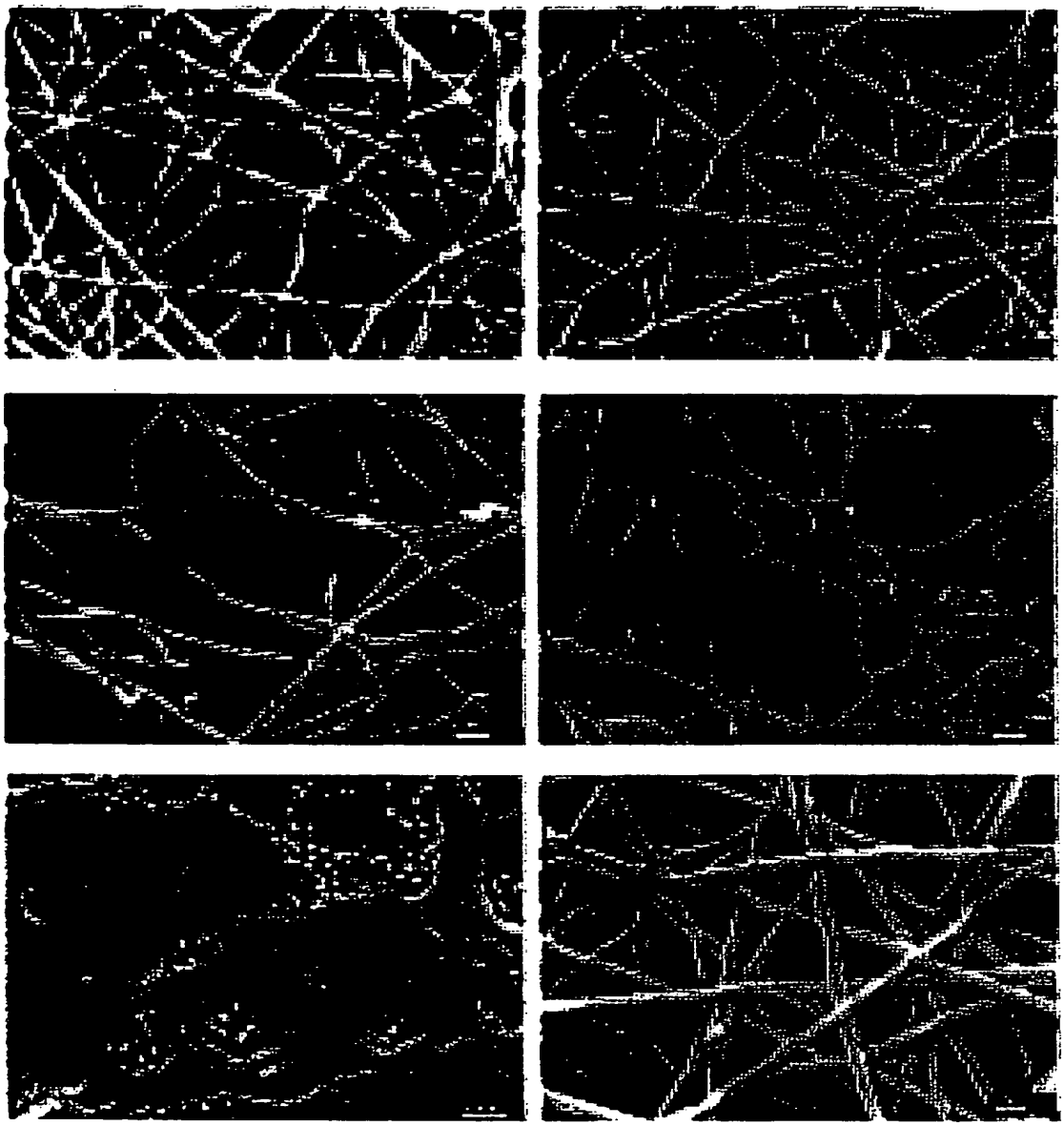


FIG. 1

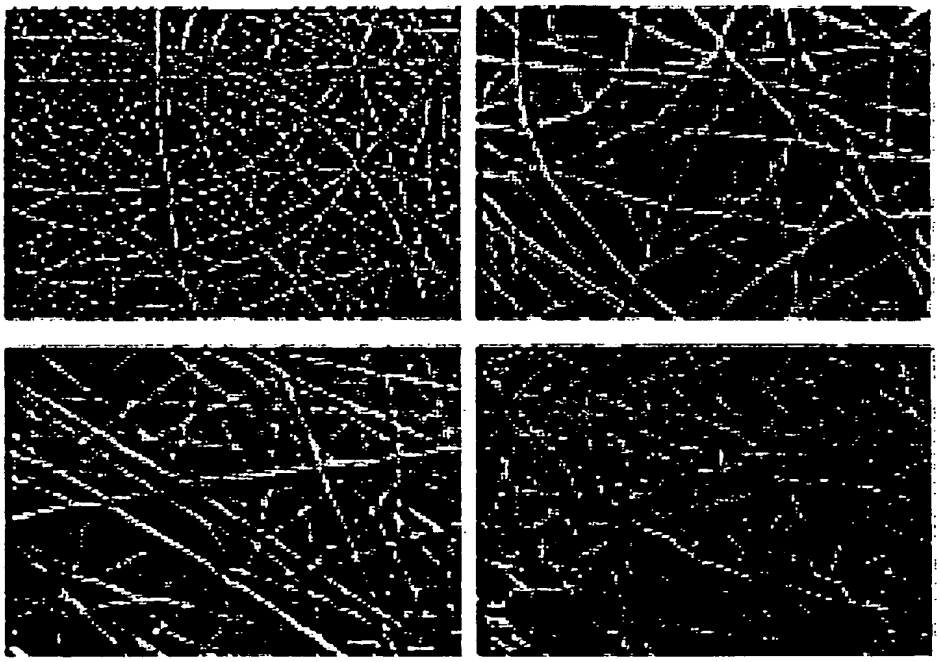


FIG. 2

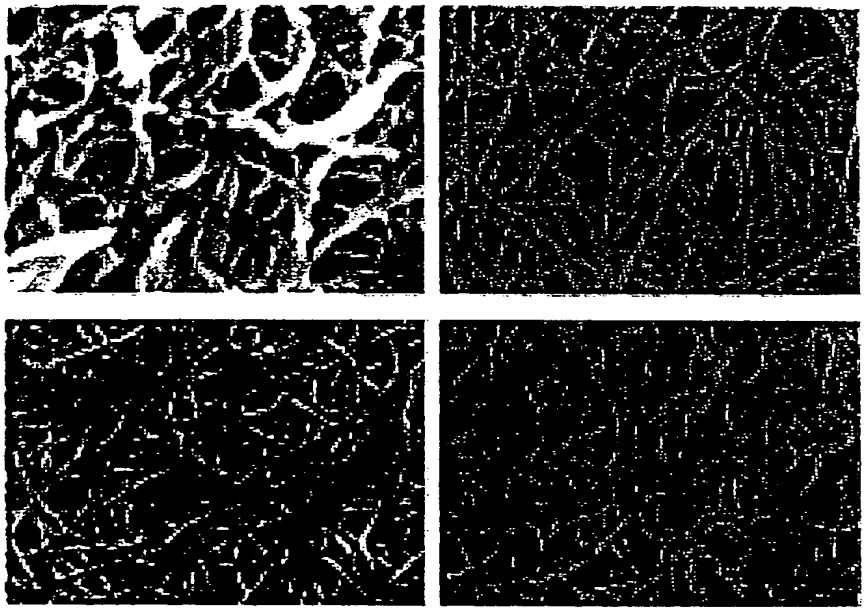


FIG. 3

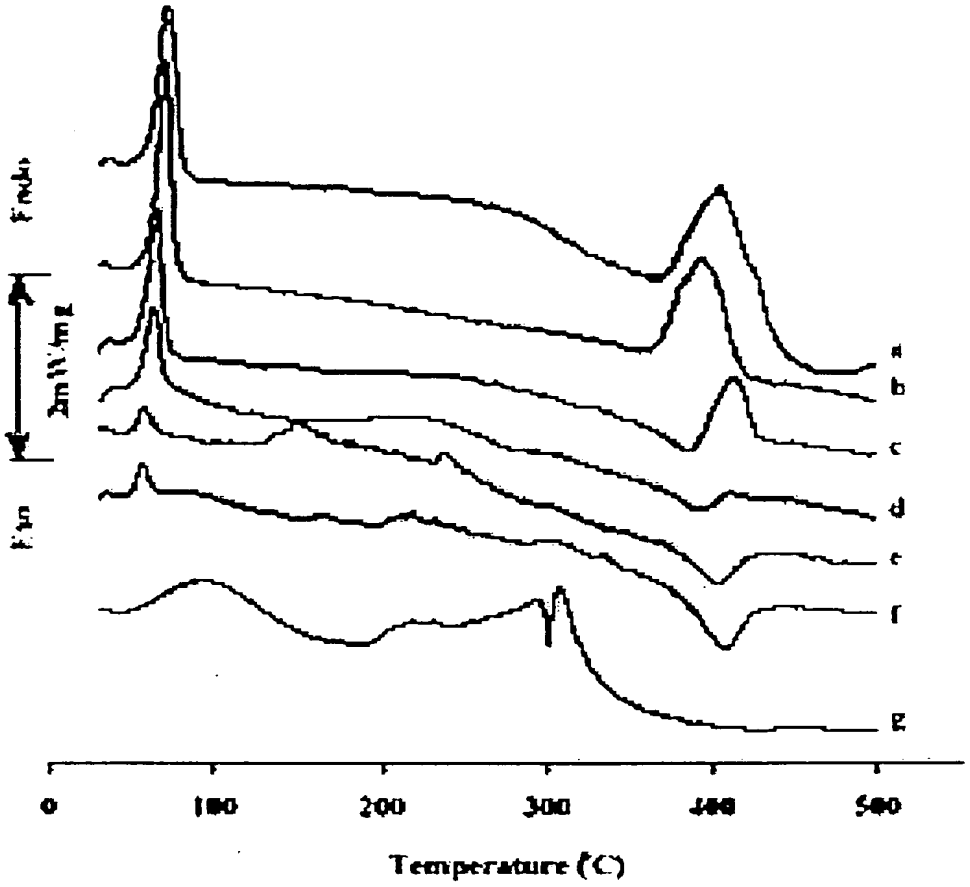


FIG. 4

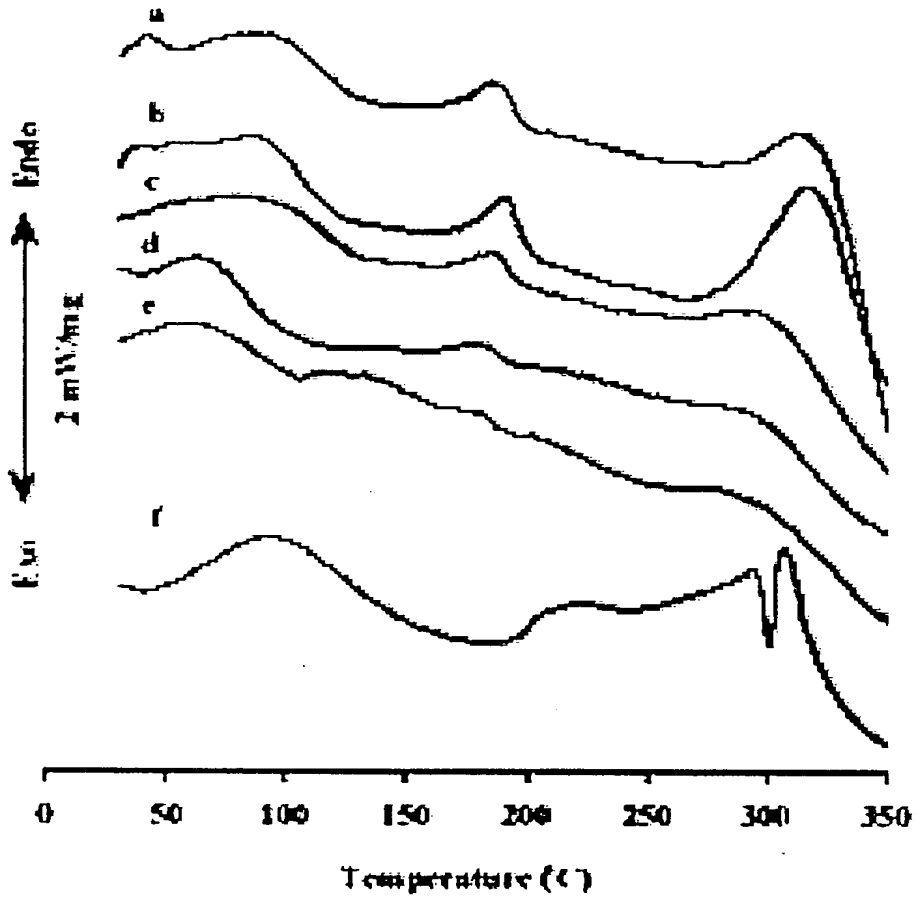


FIG. 5

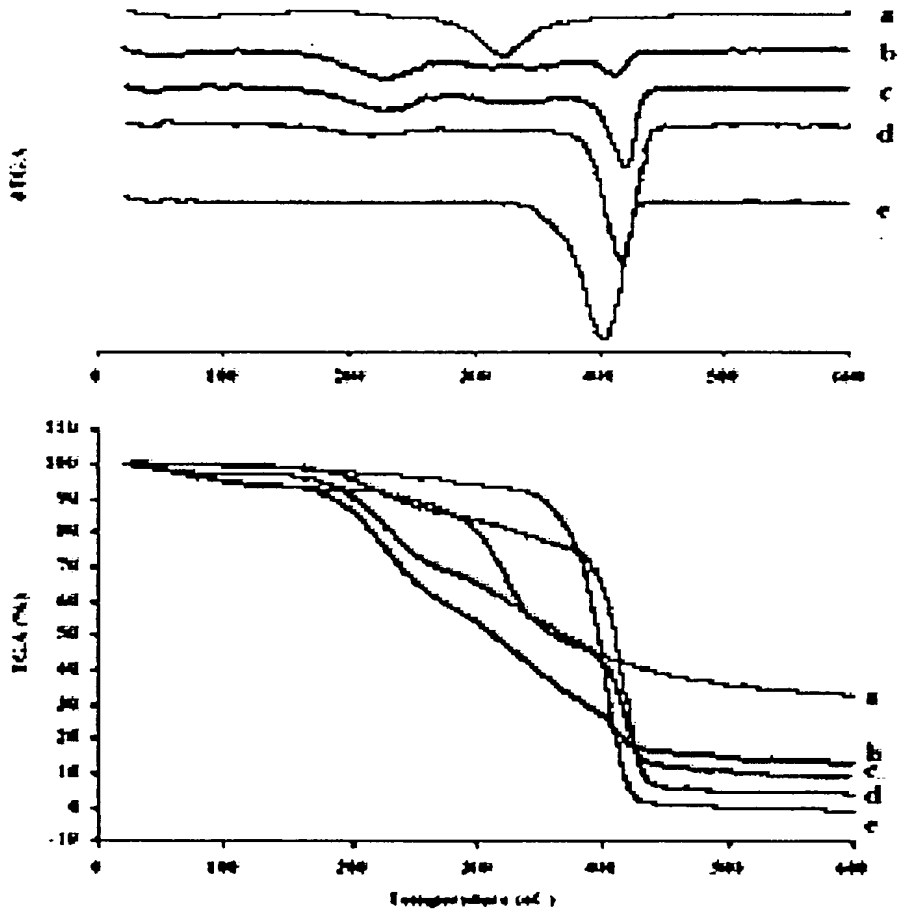


FIG. 6

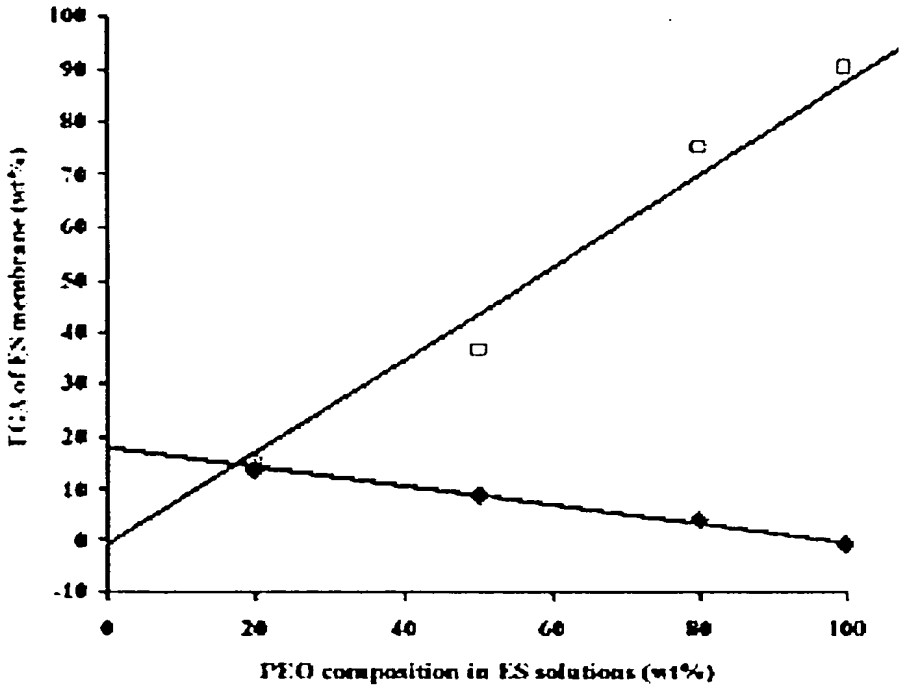

100
90
80
70
60
50
40
30
20
10
0
-10
0
20
40
60
80
100
PEO composition in ES solutions (wt%)

FIG. 7

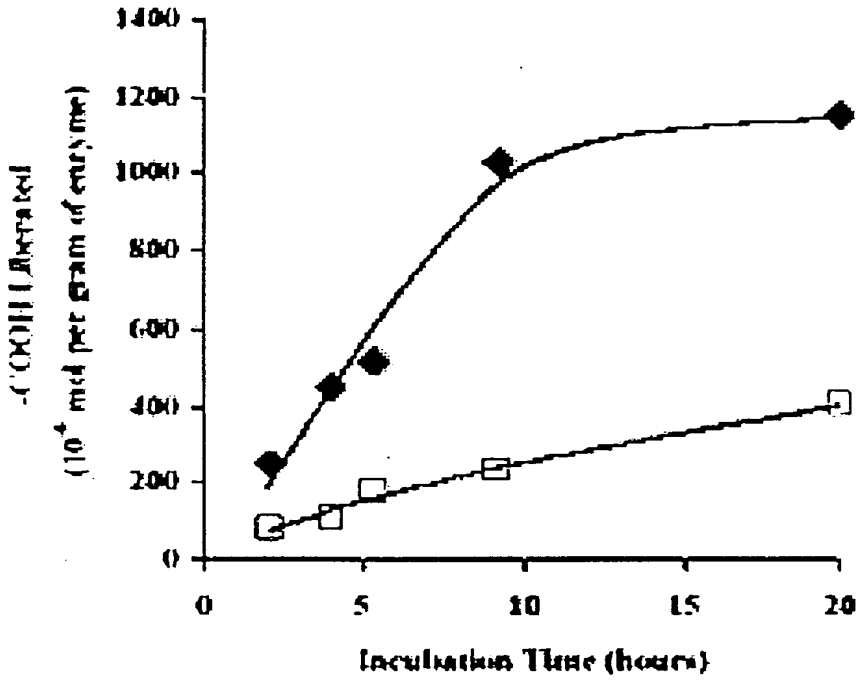

1400
1200
1000
800
600
400
200
0
0
5
10
15
20
Incubation Time (hours)

FIG. 8

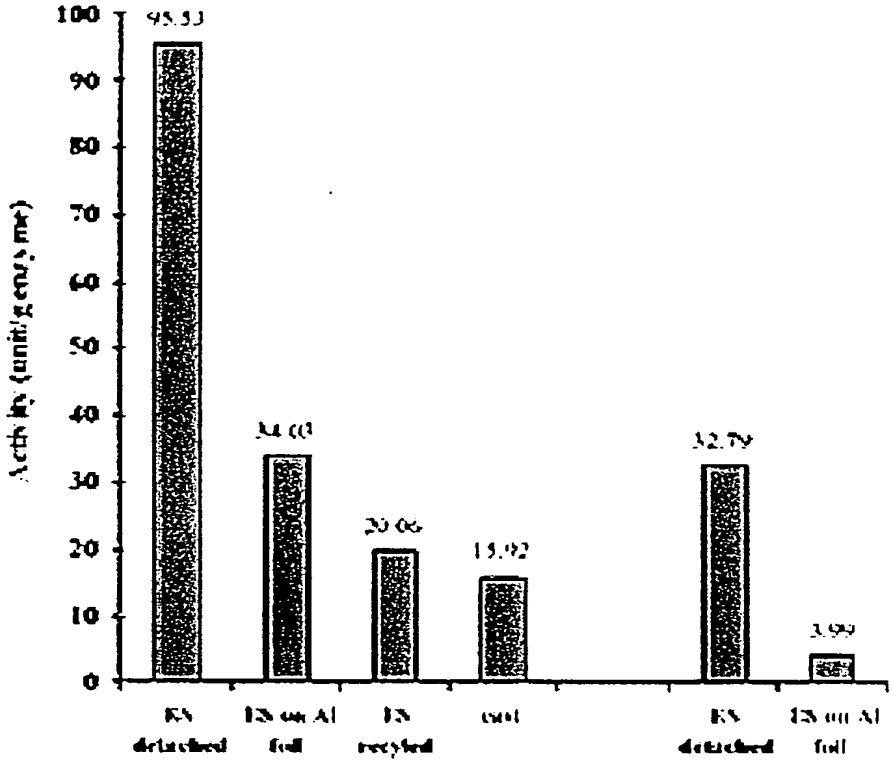

100
90
80
70
60
50
40
30
20
10
0
95.53
34.03
20.06
15.92
32.79
3.99
PS detached
PS on Al foil
PS recycled
PS
PS detached
PS on Al foil

FIG. 9

Reactive Groups on Proteins

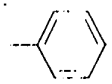
Reactive group	*Amino Acid*	*pKa*
$-NH_2$	*Lysine(ε–NH_2),N-terminal amino groups (α-NH_2)*	*10.53;9.0-9.9*
-COOH	*Asparate,Glutamate,C-terminal carboxyl groups*	*3.86;4.07;1.8-2.4*
-SH	*Cysteine*	*8.27*
-SS-	*Cystine*	—
	*Tyrosine*	*10.07*

FIG. 10A

Reactions with Protein Amine NH_2

Reactive groups		*Coupling Reaction*
Acid anhydride	*$(CO)_2O$*	*Peptide formation*
Isocyanate	*NCO*	*Peptide formation*
Acylchloride	*COCl*	*Peptide formation*
Oxirane	*$OCHXCH_2$*	*Alkylation*
Aldehdye	*CHO*	*Schiff base*

FIG. 10B

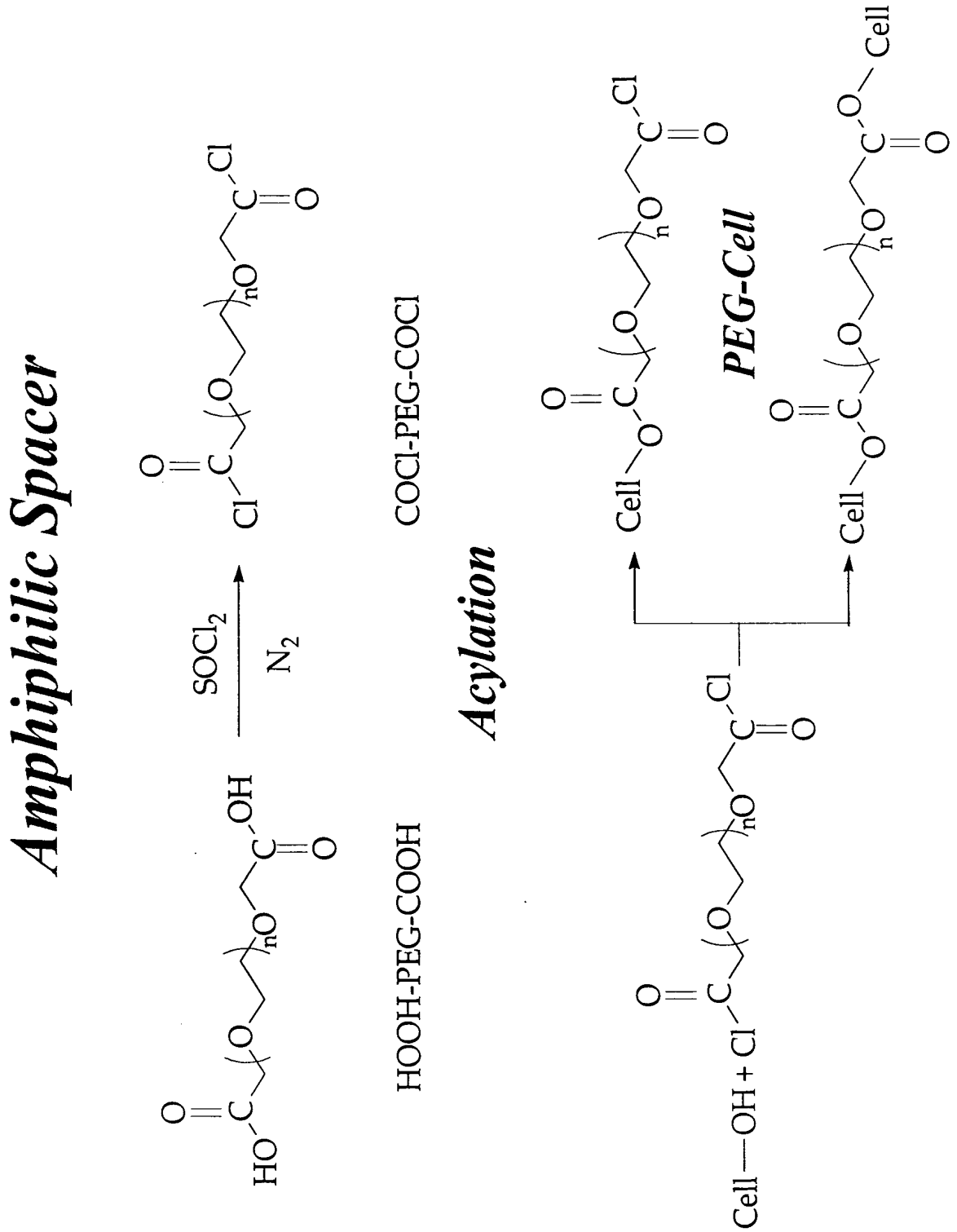

Amphiphilic Spacer
HOOH-PEG-COOH
$SOCl_2$
N_2
COCl-PEG-COCl
Acylation
PEG-Cell
Cell—OH + Cl
Attachement to Cellulose

FIG. 11

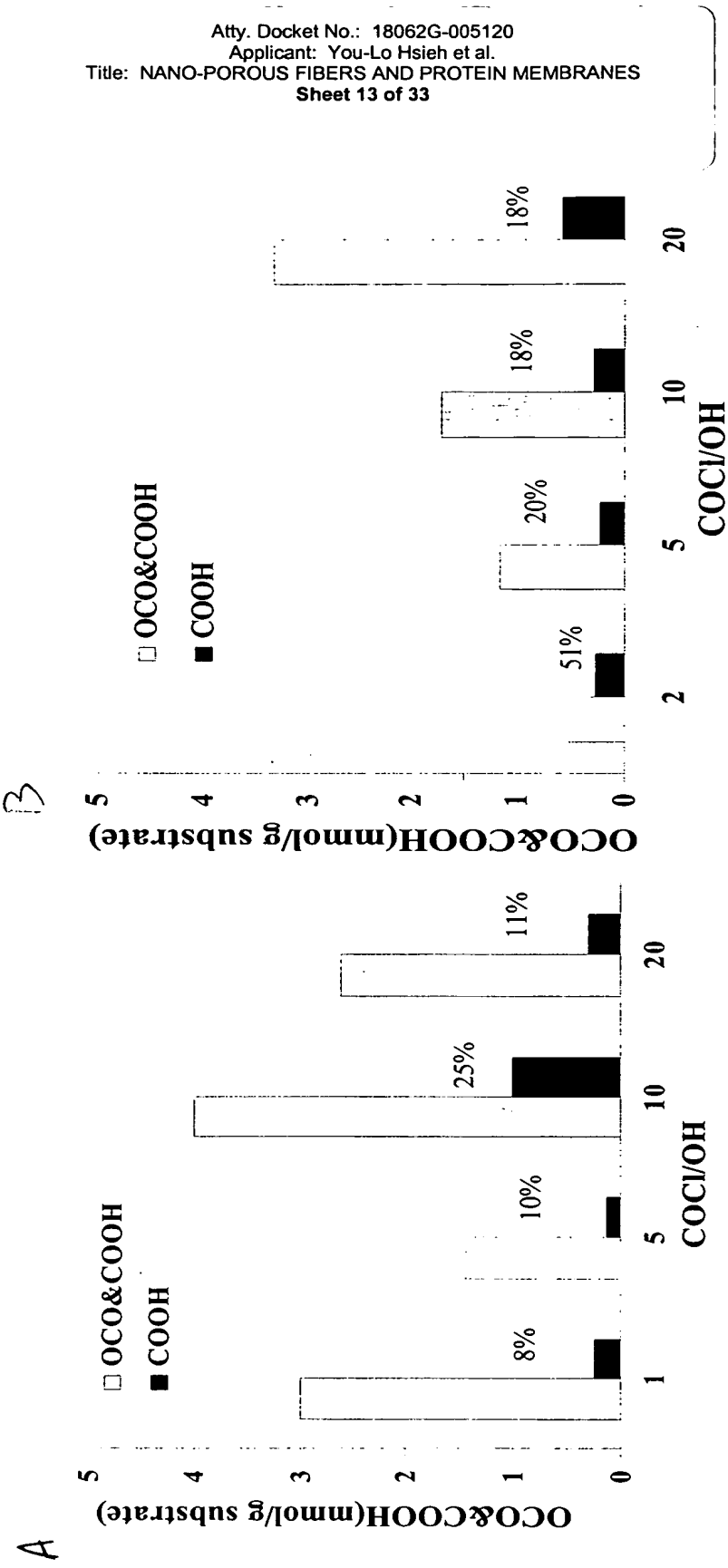

Cellulose and PEG-Cell Fibrous Membranes
Total Ester and Carboxyl Acid vs Free Acid
A
B
OCO&COOH(mmol/g substrate)
□ OCO&COOH
■ COOH
COCl/OH
8%
10%
25%
11%
51%
20%
18%
18%
PEG 600
PEG 250

FIG. 12

Coupling of Protein Amine and PEG-Cell Carboxylic via Carbodiimide

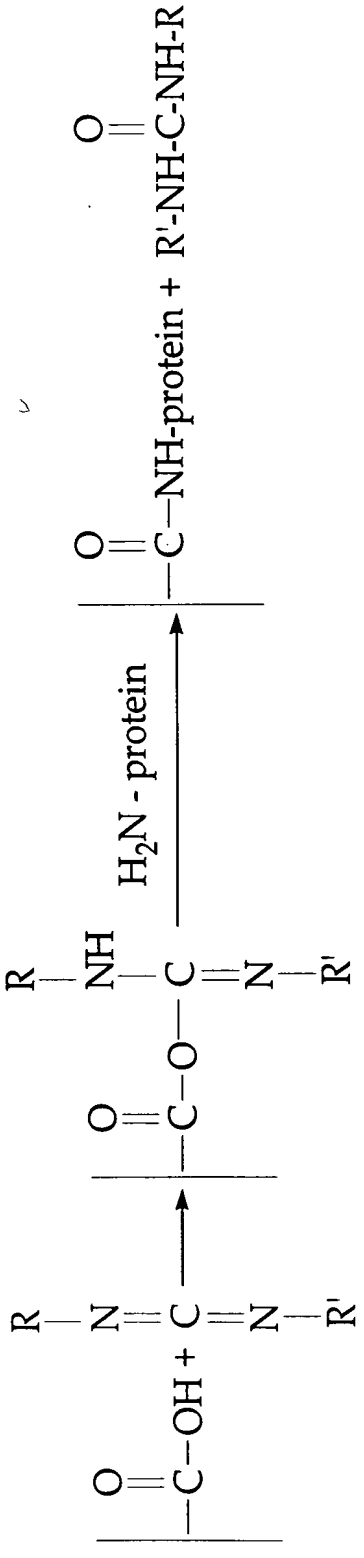
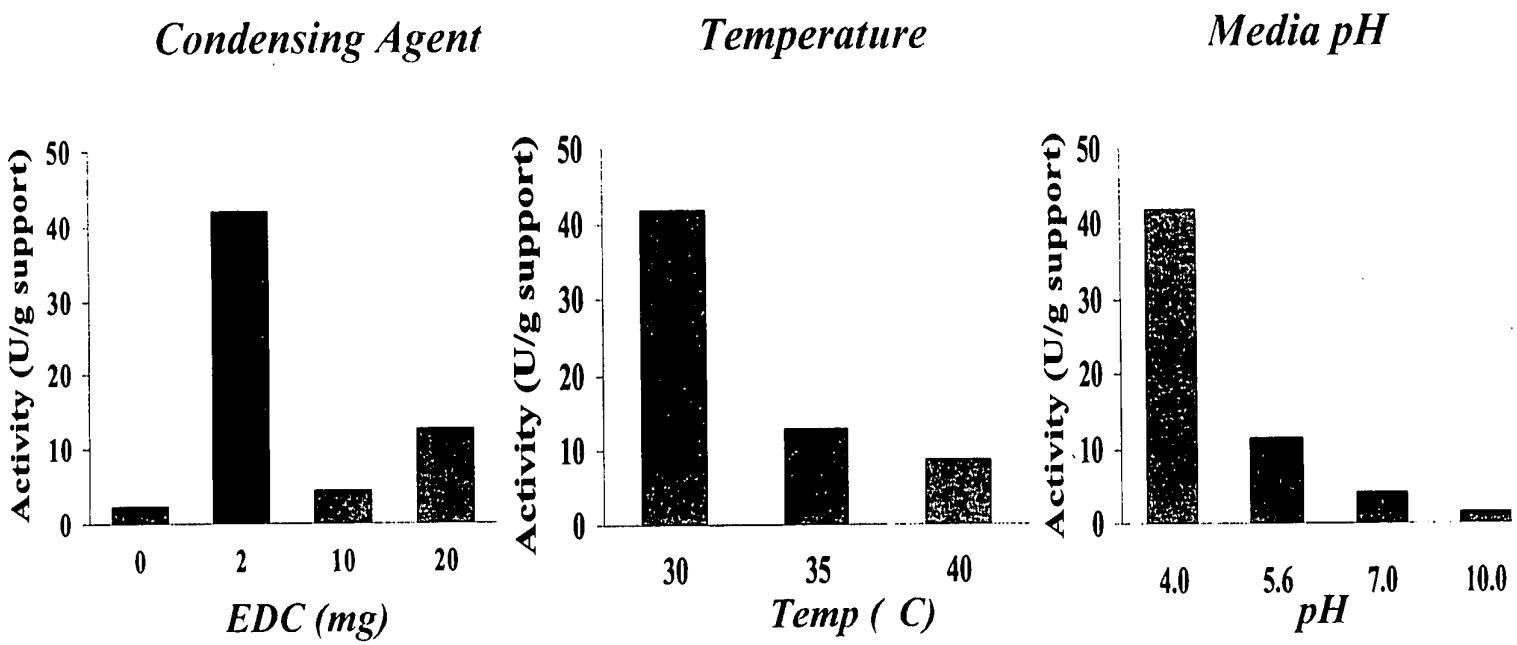


FIG. 13

Lipase-PEG-Cell Fibrous Membranes

-Coupling Reaction Conditions-

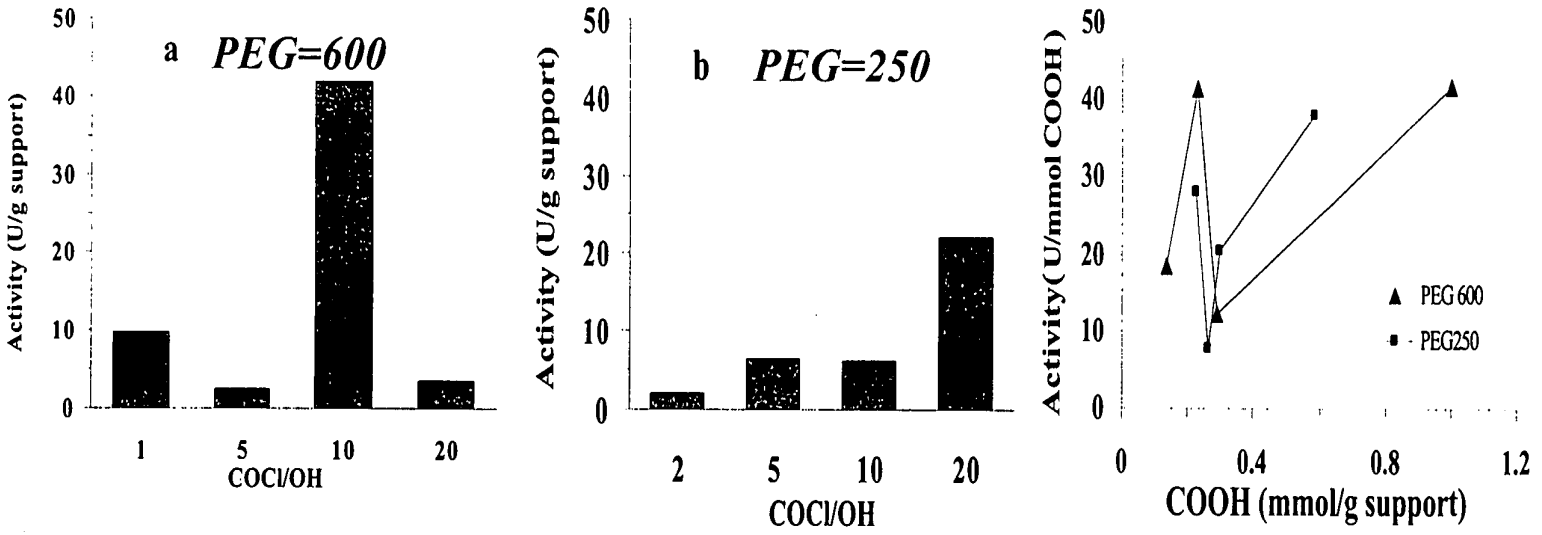


pH 4.5; 30°C *2 mg EDC; pH 4.5* *2 mg EDC; 30°C*

50 mg PEG-CELL support (PEG 600, 10 COCl/OH); 5 mg lipase;
5 ml aqueous buffer; 7 h.

FIG. 14

Lipase-PEG-Cell Fibrous Membranes
-varying COCl/OH ratios and PEG lengths-



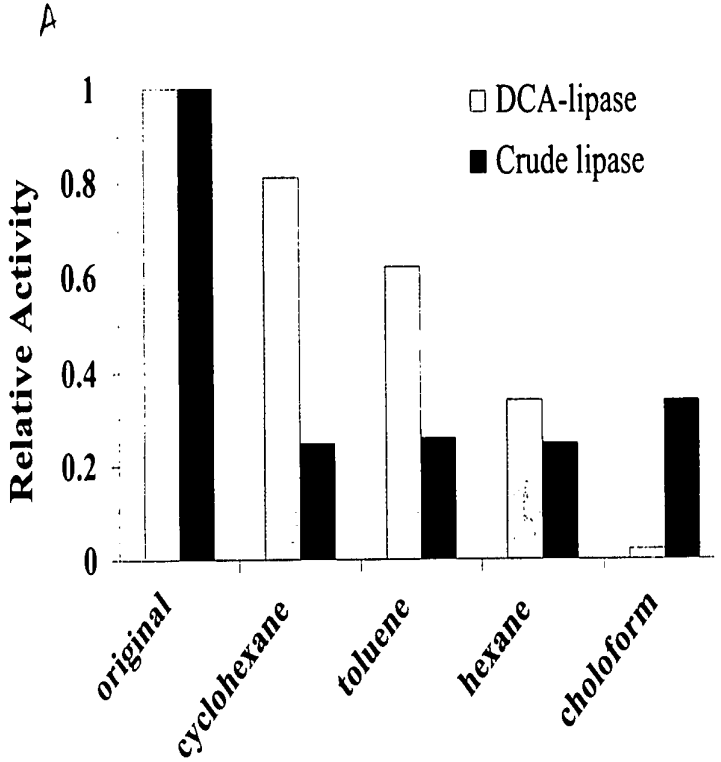
50 mg PEG-Cell support; 5 mg lipase; 2 mg EDC;
5 ml aqueous buffer (pH 4); 7 h, 30°C.

FIG. 15

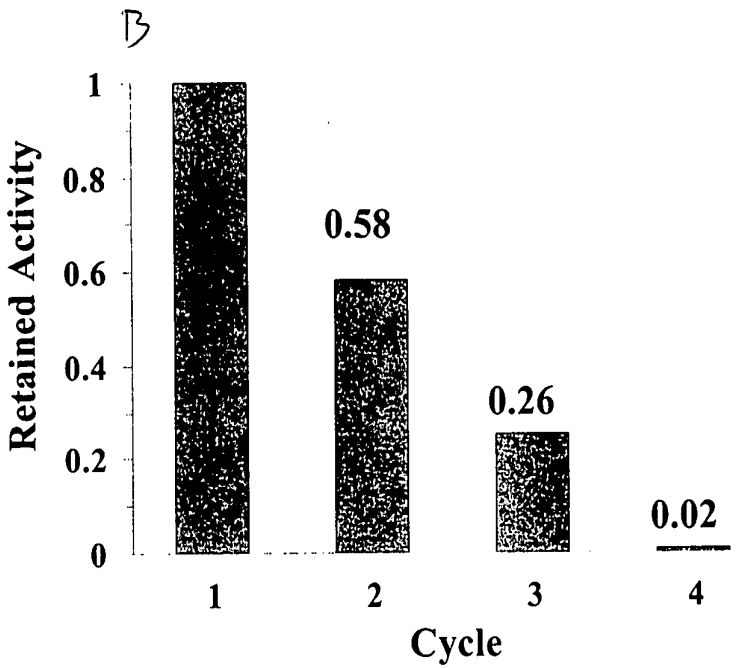
Atty. Docket No.: 18062G-005120
Applicant: You-Lo Hsieh et al.
Title: NANO-POROUS FIBERS AND PROTEIN MEMBRANES
Sheet 16 of 33

Lipase-PEG-CELL Fibrous Membranes

Stability and Reusability



50 mg PEG-Cell support (PEG600, 10 COCl/OH); 5 mg lipase; 2 mg EDC; 5 ml pH 4 buffer; 7 h, 30°C.



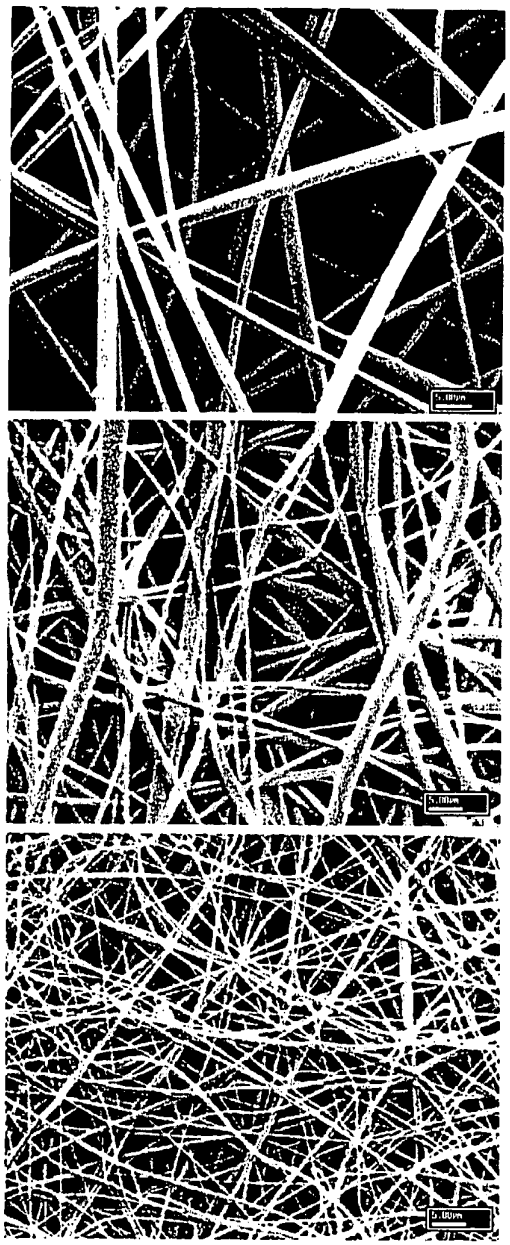
50 mg PEG-Cell support (PEG250, 20 COCl/OH); 5 mg lipase; 2 mg EDC; 5 ml pH 4 buffer; 7 h, 30°C.

FIG. 16

Atty. Docket No.: 18062G-005120
Applicant: You-Lo Hsieh et al.
Title: NANO-POROUS FIBERS AND PROTEIN MEMBRANES
Sheet 17 of 33

ES Cellulose Acetate
DS=2.45, 30,000Dalton
2:1 Acetone/DMAc

Target	*Conc.*	*Porosity* ϕ
Paper	*20%CA*	*0.95*
Water	*20%CA*	*0.76*
Water	*15%CA*	*0.43*



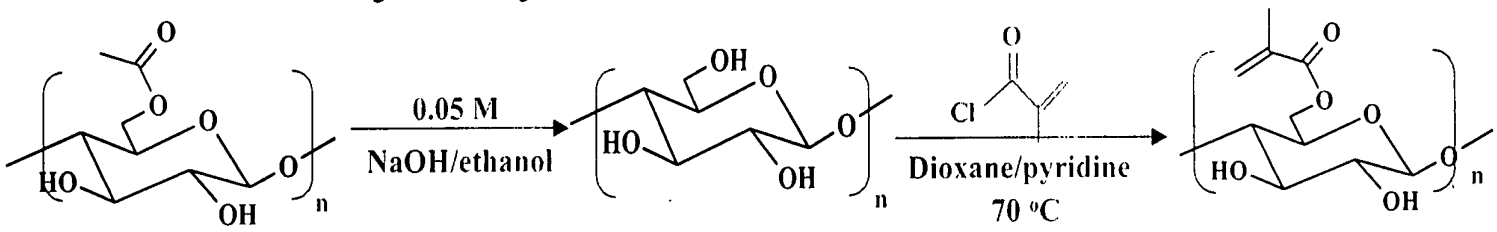
Fiber	*Pore Volume*		
	Total	*Planar*	
Diameter	C_m	C_v	C_v/C_m
nm	*µl/mg*	*µl/mg*	
≤3000	*24.8*	*17.0*	*0.69*
500-3000	*6.3*	*3.1*	*0.49*
100-500	*3.0*	*1.0*	*0.33*

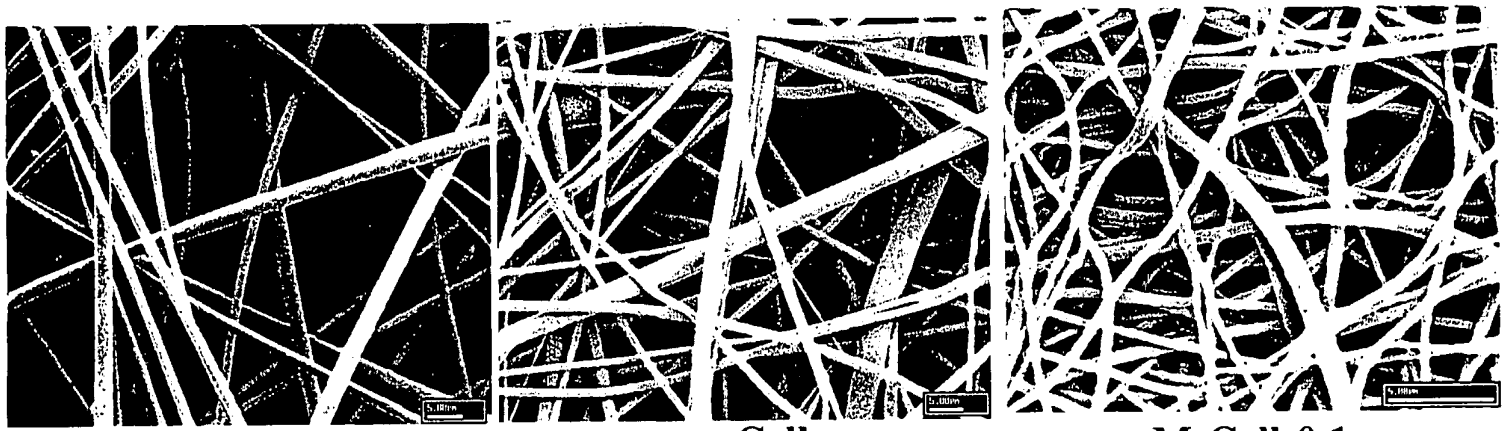
FIG. 17

Atty. Docket No.: 18062G-005120
Applicant: You-Lo Hsieh et al.
Title: NANO-POROUS FIBERS AND PROTEIN MEMBRANES
Sheet 18 of 33

Ultra-fine Cellulose Fibers

Hydrolysis and Methacrylation





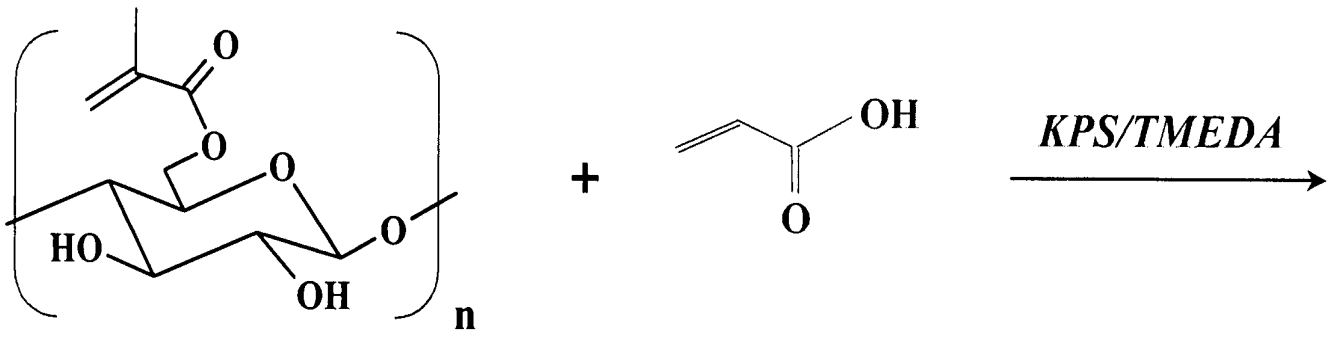
CA Cell M-Cell-0.1

	CA	*Cell*	*M-Cell-0.1*
θ_{H2O} ( )	*84*	*56*	*84*
C_m *(ul/mg)*	*17.0*	*5.2*	*4.9*
C_{H2O} *(ul/mg)*	*0*	*13.0*	*4.3*

FIG. 18

Poly(acrylic acid) Brushes on Ultra-fine Cellulose Fibers

I. FR Polymerization on M-Cell



M-CELL

$[CELL]_n$

$O\text{-}C(O)\text{-}C(CH_3)\text{-}C\text{-}C\text{-}[C\text{-}C(O)\text{-}OH]_m$

PAA-M-CELL

$\xrightarrow[pH=7\ phosphate\ buffer]{Enzyme\text{-}NH_2}$ *Enzyme-PAA-M-CELL*

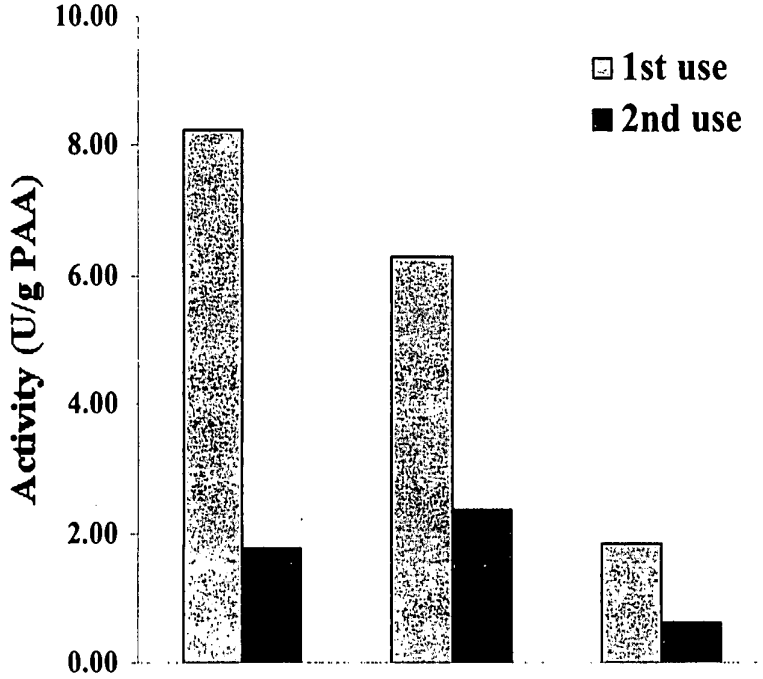
FIG. 19

Poly(acrylic acid) Brushes on Ultra-fine Cellulose Fibers

Enzyme Activity*

A

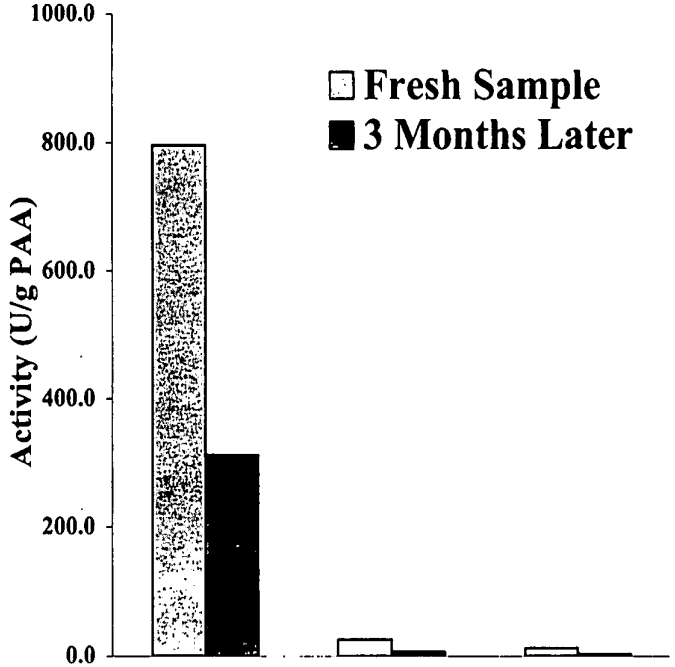
I. FR Polymerizaation on M-Cell
PAA Lengths



[AA]/[KPS] = 30 60 120
%PAA Graft = 35% 38% 50%

B

II. Ceric Ion Initiated Polymerization
PAA Density



2.3% 136% 360%

**Lipase from Candida rugosa (Sigma, EC 3.1.1.3, type VII)*

FIG. 20

Poly(acrylic acid) Brushes on Ultra-fine Cellulose Fibers
II. Ceric Ion Initiated Polymerization

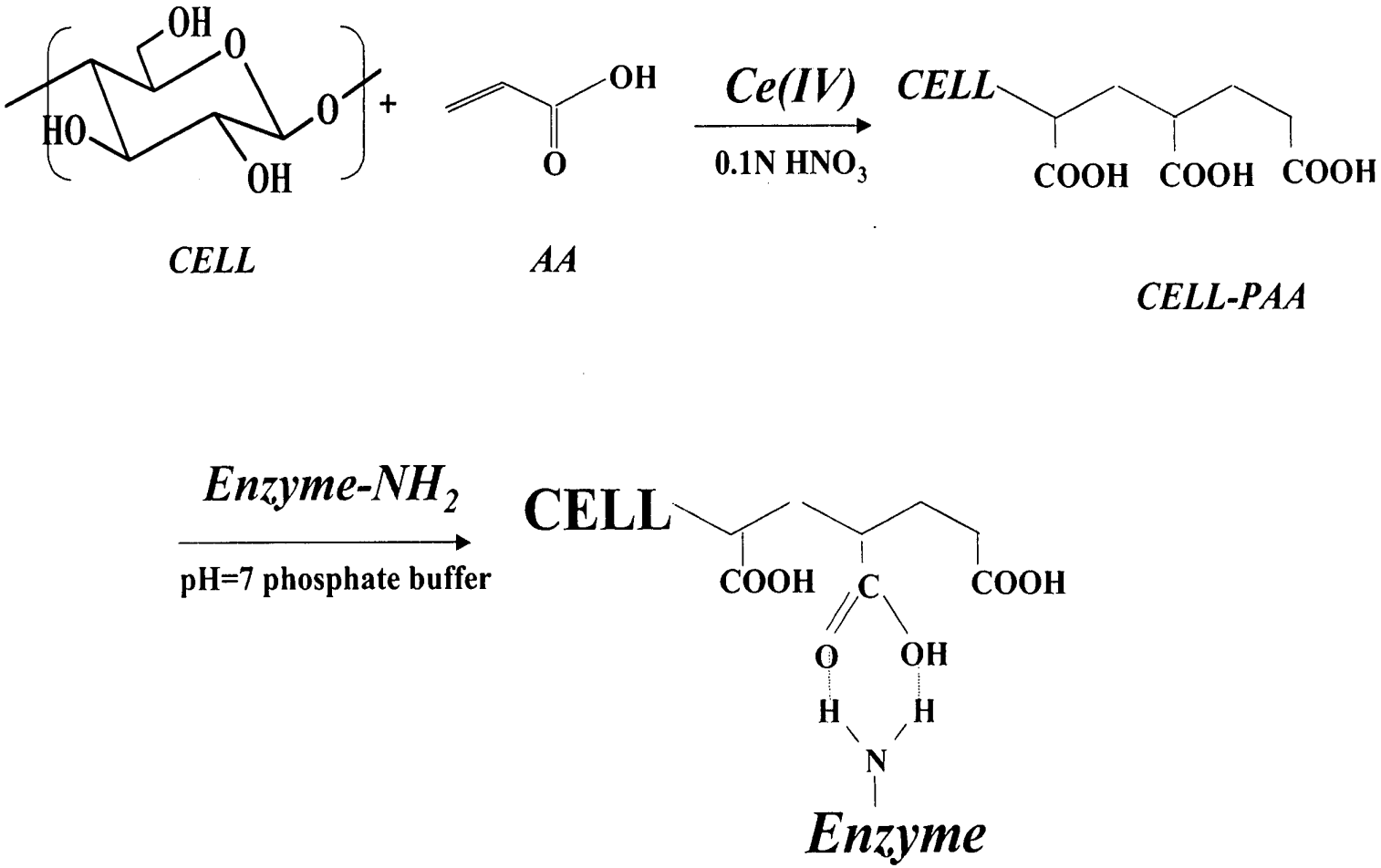
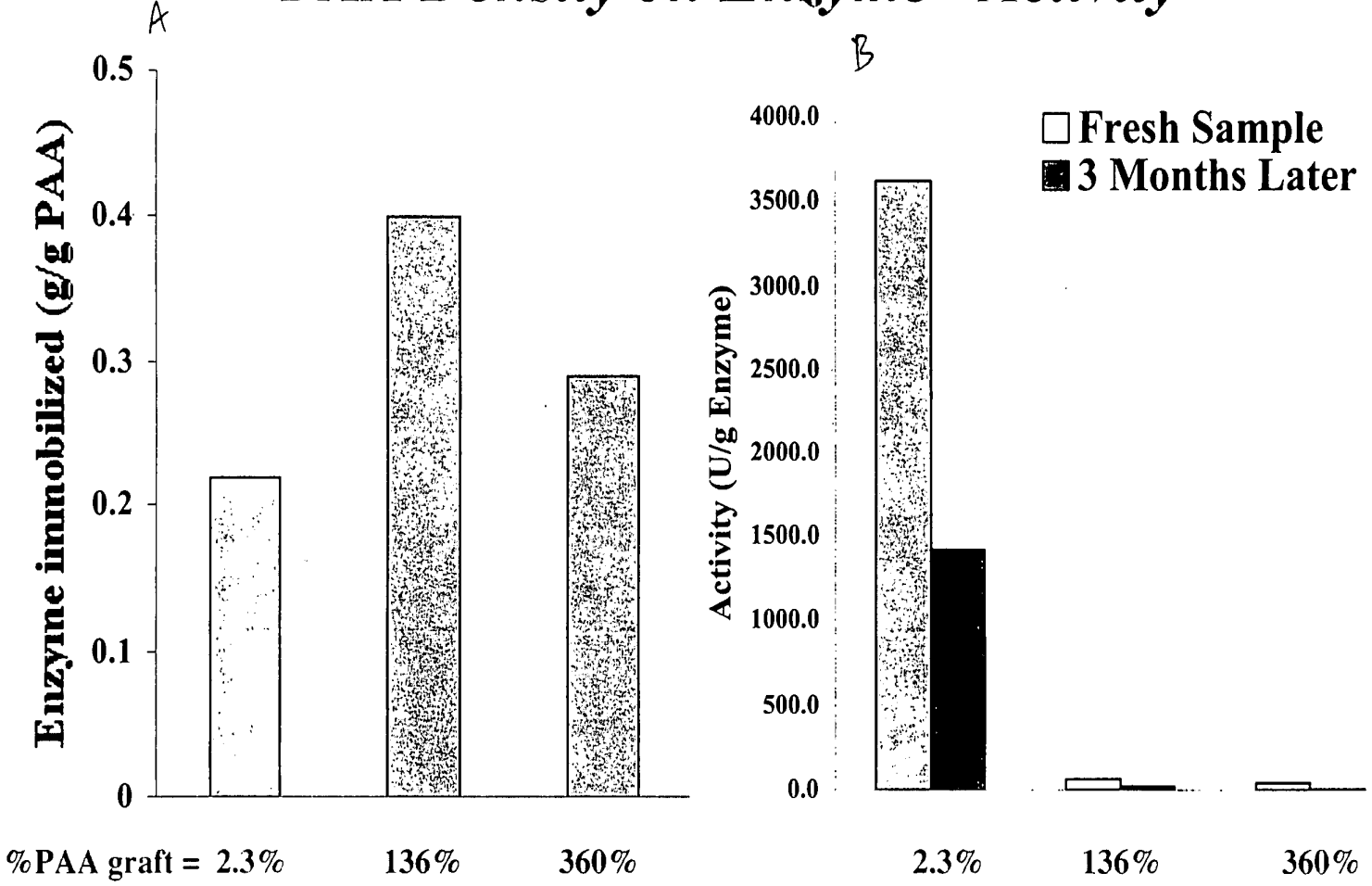


FIG. 21

Poly(acrylic acid) Brushes on Ultra-fine Cellulose Fibers
*II. Ceric Ion Initiated Polymerization^*

PAA Density on Enzyme Activity*



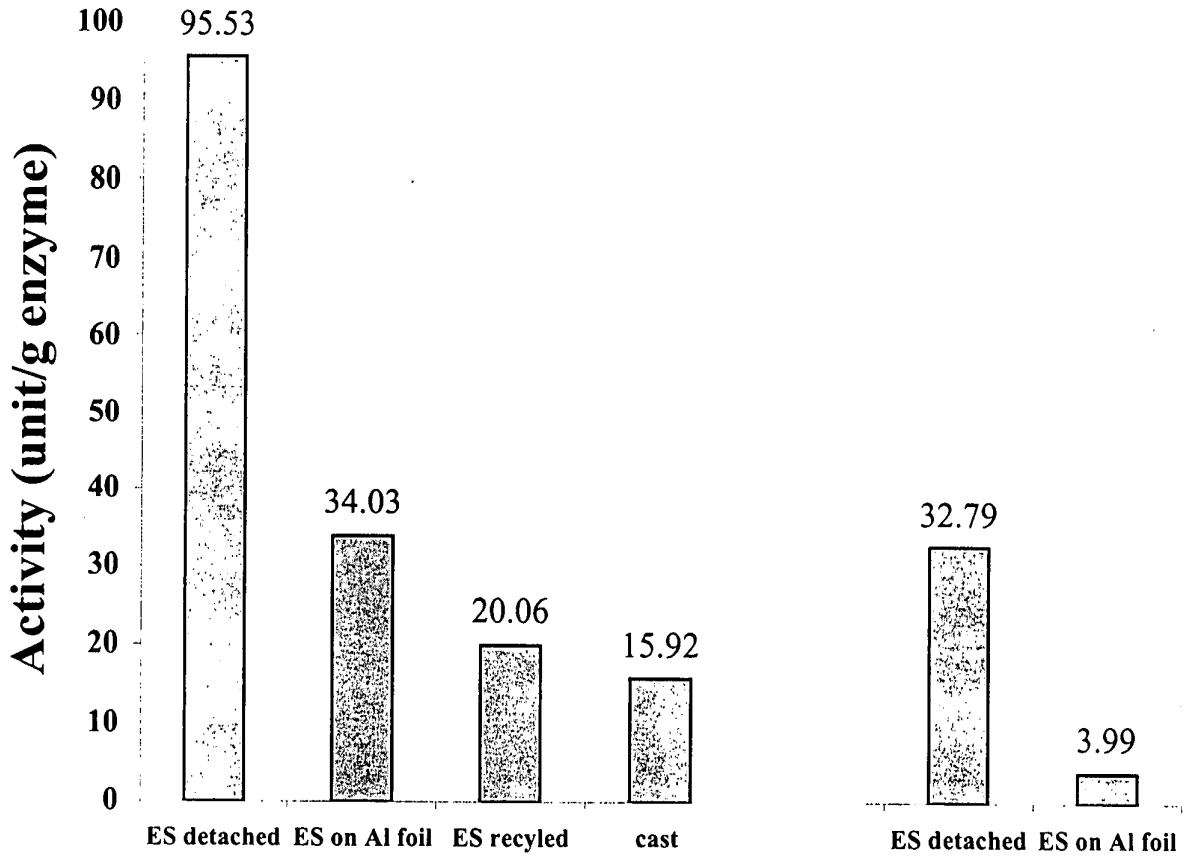
^ Varying [AA] at const. 120 [AA]/[I]

** Lipase from Candida rugosa (Sigma, EC 3.1.1.3, type VII).*

FIG. 22

Activities of Enzyme

Fibrous Protein Membranes



80:20 PVA:lipase *30:40:30 PEO:casein:lipase*

Lipase from Candida rugosa (EC 3.1.1.3, type VII)

FIG. 23

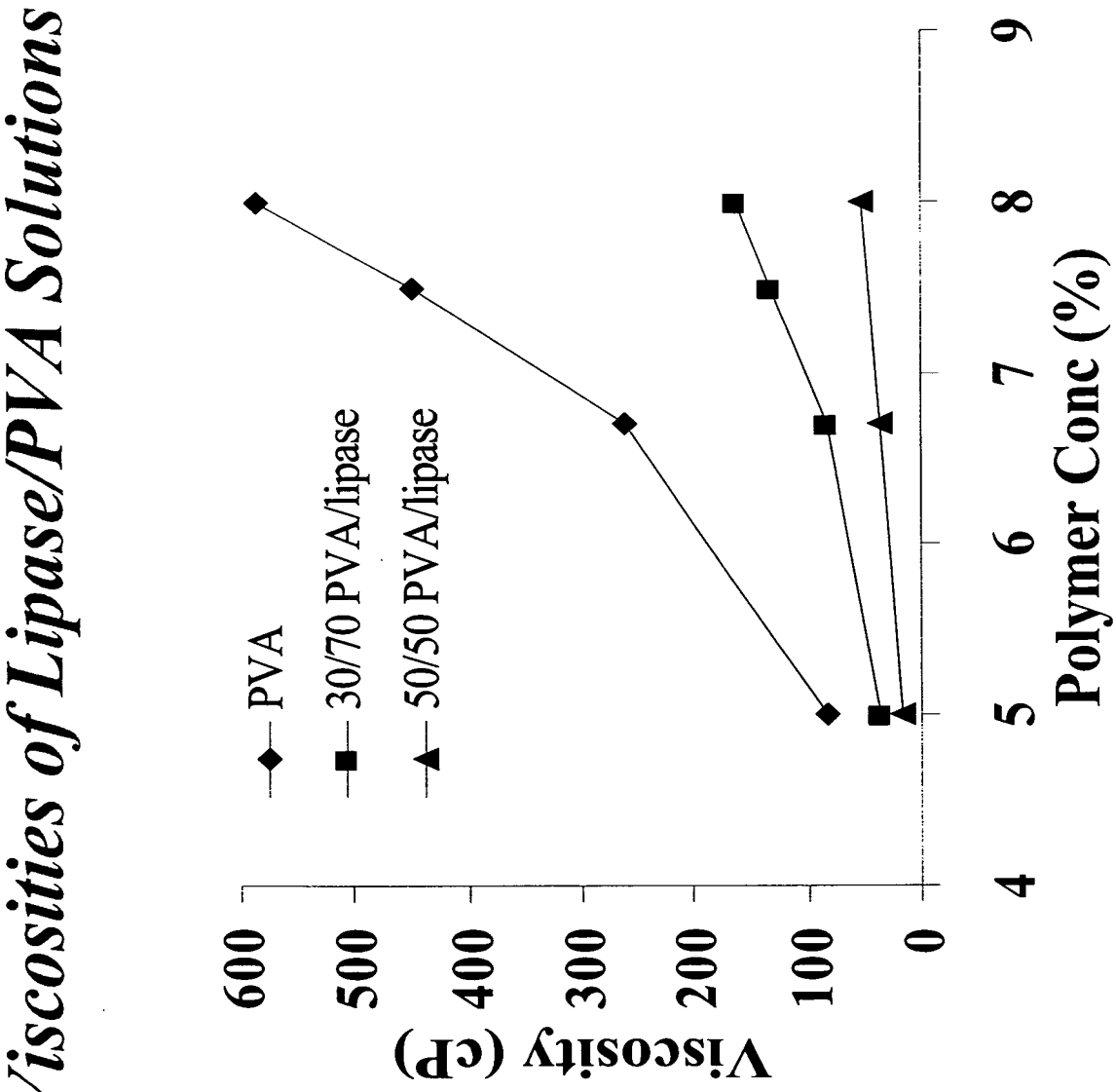
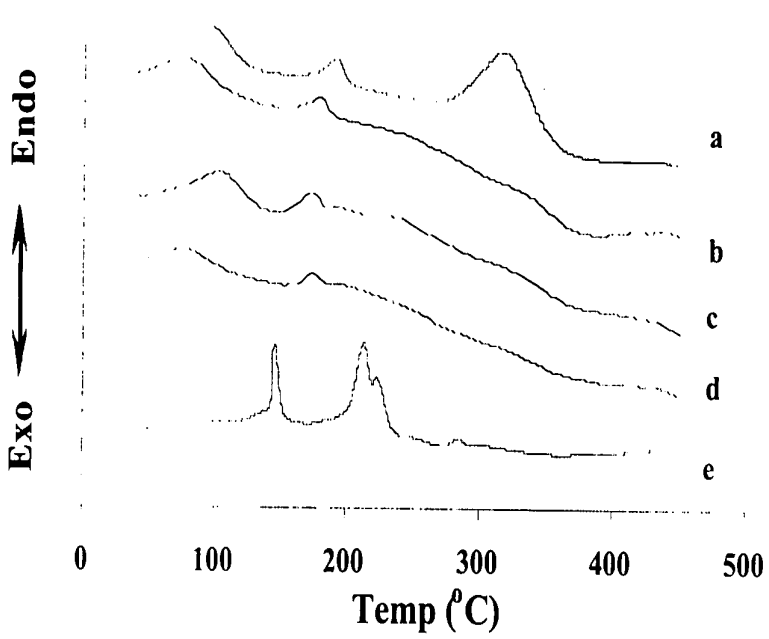

Viscosities of Lipase/PVA Solutions
Viscosity (cP)
600
500
400
300
200
100
0
4
5
6
7
8
9
Polymer Conc (%)
PVA
30/70 PVA/lipase
50/50 PVA/lipase

FIG. 24

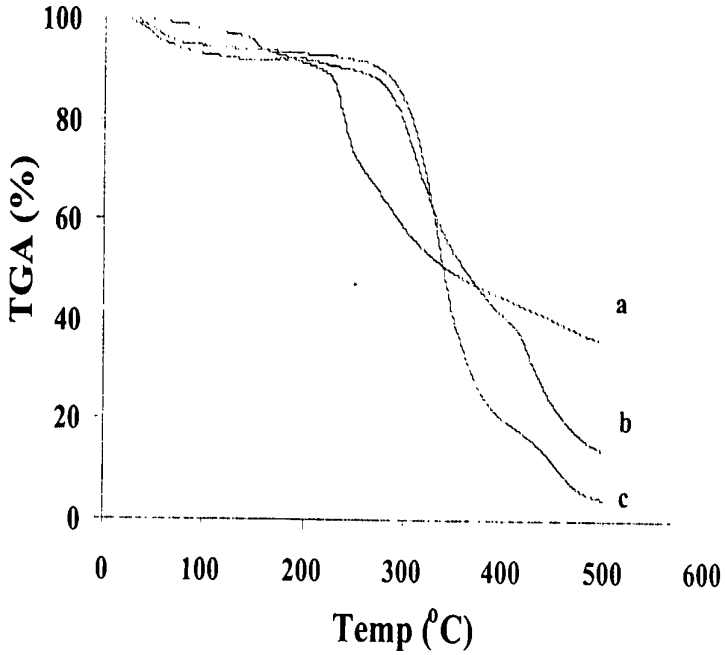
PVA/Lipase Membranes
Thermal Properties

DSC



a. ES PVA (10%)
b. 1:9 Lipase/PVA(6.7%)
c. 3:7 Lipase/PVA (6.7%)
d. 5:5 Lipase/PVA (10%)
e. Crude lipase

TGA



a. Crude lipase
b. 1:9 Lipase/PVA(6.7%)
c. ES PVA (10%)

FIG. 25

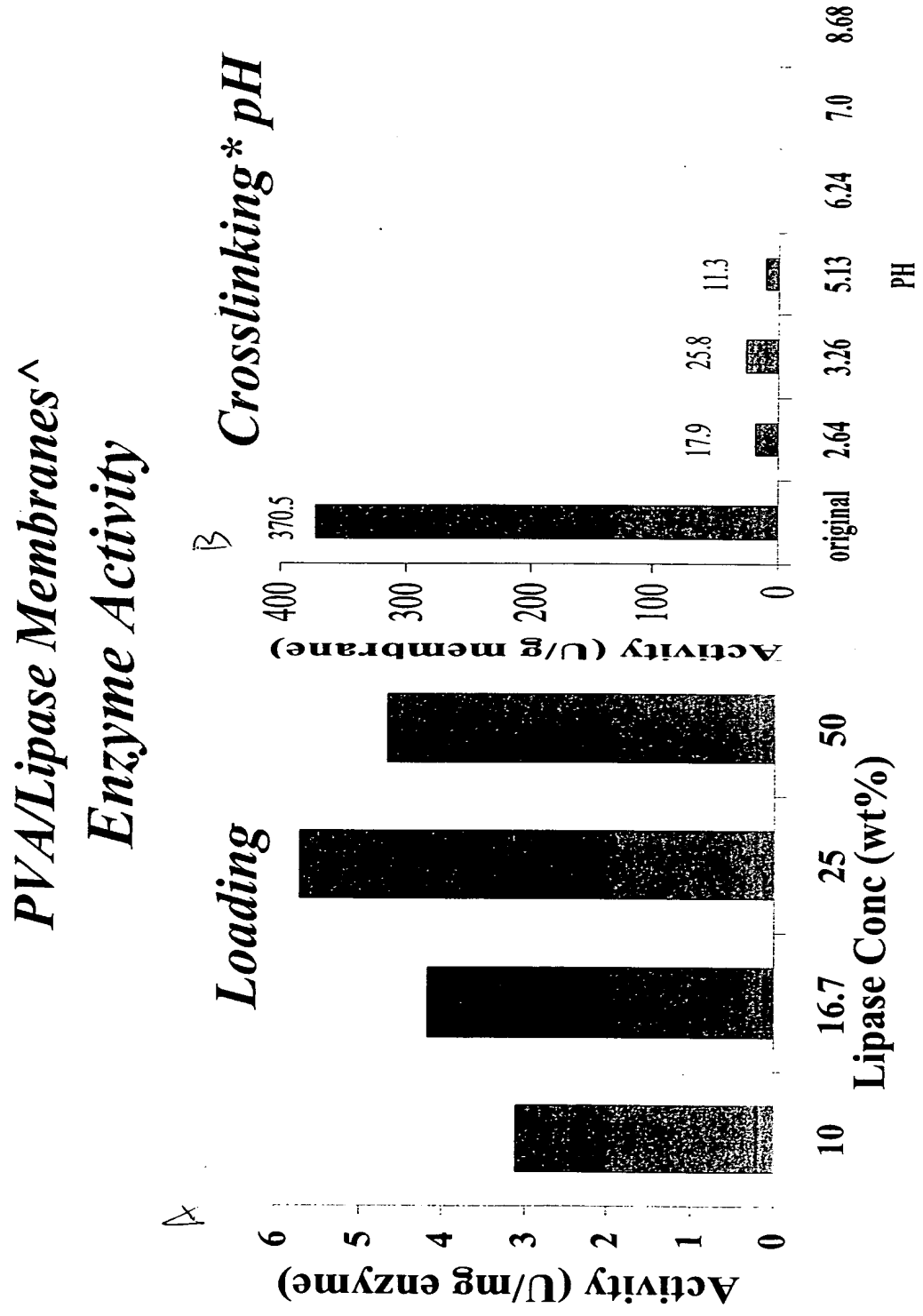
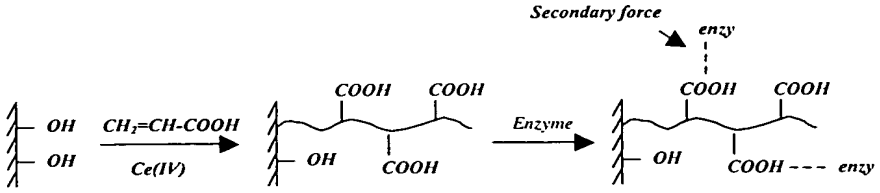

PVA/Lipase Membranes^
Enzyme Activity
A
Loading
Activity (U/mg enzyme)
0
1
2
3
4
5
6
10
16.7
25
50
Lipase Conc (wt%)
B
Crosslinking* pH
Activity (U/g membrane)
0
100
200
300
400
370.5
17.9
25.8
11.3
original
2.64
3.26
5.13
6.24
7.0
8.68
PH
^ 1:9 Lipase/PVA (6.7% aq. soln.)
* 0.1 M GA in EtOH, 6 hr, ambient temperature

FIG. 26

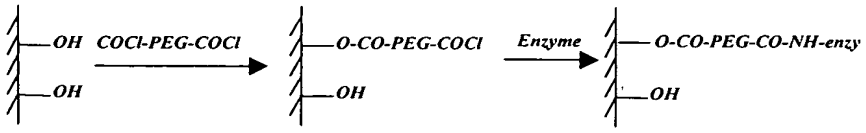
A



cellulose **polyeletrolyte graft** **enzyme adsorption**

Surface grafting of polyelectrolyte and subsequent enzyme adsorption

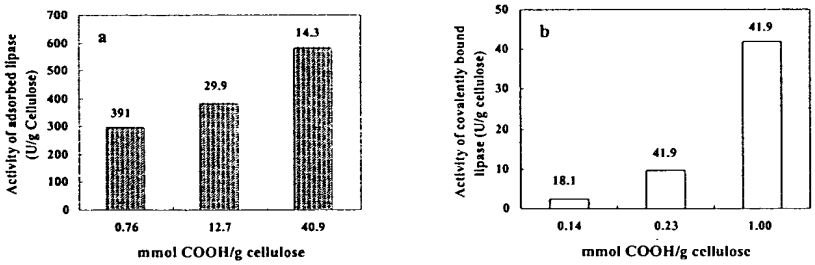
B



cellulose **PEG-attached** **covalently bound enzyme**

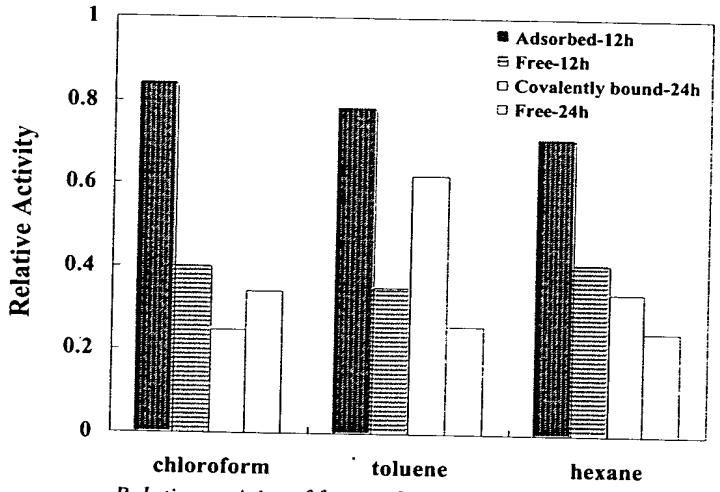
Attachment of PEG diacylchloride and subsequent enzyme binding

FIG. 27



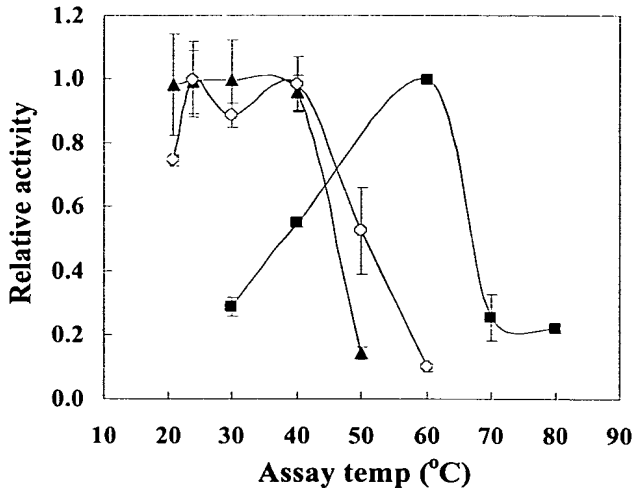
Effect of carboxylic acid quantity on the activity of bound lipase: (a) adsorbed on PAA-grafted ([AA]/[Ce(IV)]=120); (b) covalently bonded on PEG-grafted cellulose fibers.

FIG. 28



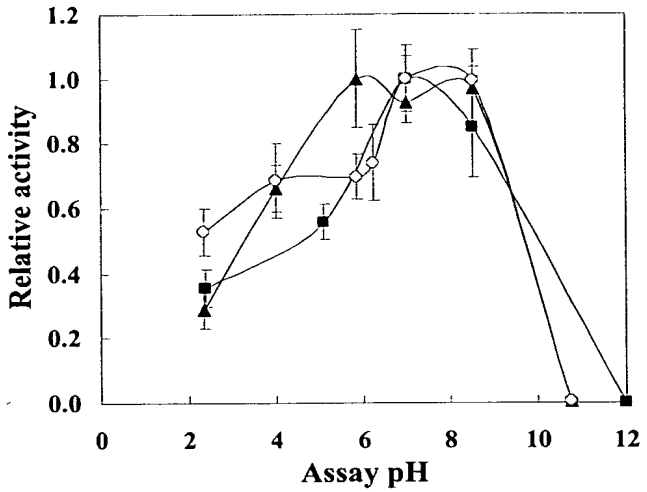
Relative activity of free and cellulose fiber bound lipase (pH=8.5,30°C) following exposure to organic solvents.

FIG. 29



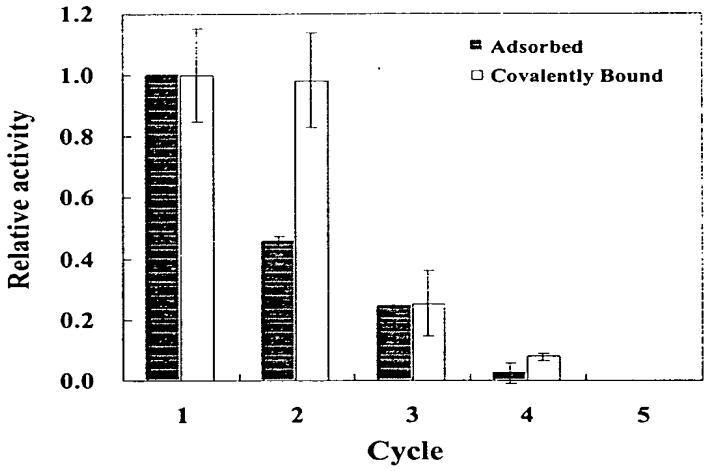
. Relative activity (pH 8.5) of free lipase (○) and bound lipase on PAA-grafted (▲) and PEG-grafted (■) cellulose fibers at various temperatures.

FIG. 30



r. Relative activity (30°C) of (○) free lipase and (▲) adsorbed lipase on PAA grafted (■) covalently bound lipase on PEG grafted cellulose fibers under various assay pHs

FIG. 31



Cyclic activity (pH 8.5, 30°C) of bound lipase on cellulose fibers.

FIG. 32